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Effect of major nutrients on yield of ginger (*Zingiber officinale* Rosc.) intercropped in coconut garden[1]

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Abstract

The effect of different levels of nitrogen, phosphorus and potassium on the yield of ginger (*Zingiber officinale* Rosc.) grown as an intercrop in a coconut garden was studied in a field experiment conducted at Coconut Research Station, Balaramapuram, Thiruvanathapuram, Kerala. Significant increases in leaf production, leaf area index and dry matter production, crop growth rate and uptake of nutrients were resulted from higher dose of fertilizers. Fertilizer recommendation for ginger grown under open condition (N:P:K @ 75:50:50 kg ha^{-1}) is insufficient for ginger intercropped in coconut gardens. A higher fertilizer dose of N:P:K @ 150:100:100 kg ha^{-1} is necessary for increasing the yield of ginger grown as an intercrop in coconut garden.

Key words: ginger, inorganic fertilizers, intercropping, yield, *Zingiber officinale*.

Abbreviations: DAP : Days after planting; CGR : Crop growth rate; DMP : Dry matter production

Introduction

Ginger (*Zingiber officinale* Rosc.) is one of the important spices cultivated in Kerala. It is cultivated in an area of 14568 ha with a production and productivity of 49946 tonnes and 3428 kg ha^{-1}, respectively (FIB 2001). Possibility of area expansion under monocropping in Kerala is limited. Therefore, utilizing the interspace in coconut gardens is a feasible approach to achieve the target production at 12 per cent annual growth rate in ginger (Chadha & Rethinam 1994). However, information on the influence of inorganic nutrients on growth parameters, uptake of nutrients and rhizome yield of ginger grown as intercrop in coconut garden is scanty. The investigation was undertaken to study the effect of different levels of N, P and K on growth and rhizome yield of ginger grown as an intercrop in coconut garden.

Materials and methods

The field experiment was conducted at Coconut Research Station, Balaramapuram, Kerala during 1996-97 and 1997-98. The soil of the experimental site was red loam with a pH 4.5 and low in available N (195 kg ha^{-1}), medium in P_2O_5 (24.30 kg ha^{-1}) and low in K_2O (94.40 kg ha^{-1}). The ginger cv. Rio-de-Janeiro was used for the study. Farm yard manure @ 30 t ha^{-1} in the form of cowdung and green leaf mulch @ 30 t ha^{-1} were applied as per the recommendation (KAU 1996).

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The experiment comprising three levels each of nitrogen (N_0=0, N_1=75, N_2= 50 kg ha^{-1}), phosphorus (P_0=0, P_1=50, P_2=100 kg ha^{-1}) and potassium (K_0=0, K_1=50, K_2=100 kg ha^{-1}) was laid out in 3 x 3 factorial experiment in randomized block design and replicated thrice. For all treatments, full dose of P_2O_5 and half dose of K_2O were given as basal dressing, half the dose of N at 60 days after planting and remaining portions of N and K_2O were applied at 120 days after planting. Leaf number, leaf area index (LAI) and dry matter production (DMP) were recor-ded at 180 days after planting. LAI was com-puted using the formula suggested by Williams (1946). Crop growth rate (CGR) was determi-ned by the method of Watson (1958). Nutrient contents in leaf, pseudostem, rhizome and root were estimated by adopting the procedures suggested by Jackson (1973). Total uptake was estimated by multiplying nutrient content and total dry weight and expressed in kg ha^{-1}. The crop was harvested at 240 days after planting and rhizome yield (dry) was recorded.

Results and discussion

Number of leaves

Increasing rate of N up to 150 kg ha^{-1} and P_2O_5 up to 100 kg ha^{-1} significantly increased number of leaves per plant (Table 1). However, the increasing rate of K_2O had no significant effect on leaf production. Among the interactions (Table 2), when N was applied at 150 kg ha^{-1}, significantly higher number of leaves was obtained with 100 kg P_2O_5 ha^{-1}. In general, higher levels of N, P and K enhanced the production of leaves. Enhanced vegetative growth as a result of higher levels fertilizers was reported in ginger grown under artificial shade (Ancy & Jayachandran 1996).

Leaf Area Index (LAI)

Nitrogen at 150 kg ha^{-1} was found to increase the LAI of ginger (Table 1). Significantly higher LAI was recorded at 100 kg ha^{-1} each of P_2O_5 and K_2O. The interactions indicated that if N is increased there should be a proportionate

Table 1. Effect of N, P and K on number of leaves, leaf area index and dry matter production in ginger at 180 days after planting

Treatment	Number of leaves $plant^{-1}$		Leaf area index		DMP (g $plant^{-1}$)	
	1996-97	1997-98	1996-97	1997-98	1996-97	1997-98
N_0	109.71	111.97	9.30	9.71	32.89	31.46
N_1	151.75	152.32	12.85	13.39	53.47	53.87
N_2	159.96	153.03	12.94	13.31	81.92	80.15
F test	S	S	S	S	S	S
P_0	128.78	135.64	10.82	11.83	52.11	51.29
P_1	142.53	137.94	11.83	12.07	54.61	54.42
P_2	150.10	143.74	12.43	12.52	61.56	59.77
F test	S	NS	S	NS	S	S
K_0	138.19	142.24	11.55	12.35	51.93	52.17
K_1	137.99	134.76	11.47	11.82	57.34	55.87
K_2	145.24	140.32	12.07	12.24	59.01	57.44
F test	NS	NS	S	NS	S	NS
SEm ±	3.106	4.404	0.18	0.37	1.332	1.599
CD (0.05)	8.798	12.476	0.51	1.04	3.773	4.530

S = Significant; NS = Non significant; DMP = Dry matter production.

Table 2. Effect of N, P and K interactions on number of leaves, leaf area index and dry matter production in ginger at 180 days after planting

Nutrient level	Number of leaves plant^{-1}		Leaf area index		DMP (g plant^{-1})	
	1996-97	1997-98	1996-97	1997-98	1996-97	1997-98
N_0P_0	102.30	115.28	9.05	9.96	30.52	28.86
N_0P_1	118.11	116.53	9.89	10.13	31.64	29.66
N_0P_2	108.71	104.09	8.95	9.03	36.51	36.03
N_1P_0	134.38	144.67	11.66	12.73	47.86	50.14
N_1P_1	160.48	157.34	13.65	13.93	52.71	52.67
N_1P_2	160.39	154.96	13.24	13.52	59.84	58.80
N_2P_0	149.67	146.98	11.76	12.79	77.97	75.03
N_2P_1	149.00	139.93	11.97	12.16	79.47	80.93
N_2P_2	181.20	172.18	15.10	15.00	88.32	84.48
F test	S	S	S	S	NS	NS
N_0K_0	112.29	122.29	9.85	10.65	30.04	29.13
N_0K_1	107.87	107.91	9.02	9.35	34.26	32.50
N_0K_2	108.97	105.70	9.02	9.12	34.38	32.74
N_1K_0	143.93	146.36	11.94	12.70	50.68	52.46
N_1K_1	151.87	152.57	13.23	13.58	55.42	54.27
N_1K_2	159.44	158.04	13.39	13.91	54.31	54.87
N_2K_0	158.33	158.07	12.85	13.71	75.06	74.90
N_2K_1	154.22	143.80	12.17	12.54	82.36	80.83
N_2K_2	167.31	157.22	13.81	13.68	88.34	84.72
F test	NS	NS	S	NS	NS	NS
P_0K_0	140.01	148.51	11.15	12.88	46.79	50.18
P_0K_1	130.47	141.29	11.21	12.20	55.84	52.45
P_0K_2	115.87	117.12	10.10	10.39	53.71	51.22
P_1K_0	128.32	132.38	10.77	11.49	52.57	50.72
P_1K_1	143.04	132.32	11.88	11.84	56.80	57.84
P_1K_2	156.22	149.11	12.85	12.88	54.46	54.70
P_2K_0	146.22	145.82	12.71	12.69	56.42	55.59
P_2K_1	140.44	130.67	11.33	11.43	59.39	57.30
P_2K_2	163.63	154.73	13.26	13.43	68.87	66.41
F test	S	S	S	S	S	NS
SEm ±	5.379	7.629	0.31	0.64	2.307	2.769
CD (0.05)	15.238	21.609	0.89	1.80	6.535	-

S = Significant; NS = Non significant; DMP = Dry matter production.

increase in P and K for better LAI (Table 2). Similar finding was reported when ginger was grown under shaded condition (Ancy & Jayachandran 1996).

Dry Matter Production (DMP)

Higher levels of N and P significantly increased DMP (Table 1). The interactions indicated that if N is increased there should be a proportionate increase in P and K for better DMP (Table 2). Higher levels of N produced a significant effect on DMP (Johnson 1978). A general trend of increase in DMP with increase in fertilizer dose, when ginger was grown under open and low shade levels (25 and 50 per cent), was reported by Ancy (1992).

Crop Growth Rate (CGR)

During the first phase (60 to 120 DAP) of crop growth, increase in levels of N and P_2O_5 significantly increased the CGR (Table 3). During the second phase (120 to 180 DAP), the effect of N was significant on CGR during both

Table 3. Effect of N, P and K on crop growth rate

Treatment	Crop growth rate (g m^{-2} day^{-1})			
	60 to 120 DAP		120 to 180 DAP	
	1996-97	1997-98	1996-97	1997-98
N_0	0.25	0.23	0.34	0.33
N_1	0.32	0.35	0.71	0.70
N_2	0.43	0.44	1.19	1.16
F test	S	S	S	S
P_0	0.29	0.30	0.70	0.68
P_1	0.32	0.33	0.73	0.72
P_2	0.39	0.38	0.81	0.79
F test	S	S	S	NS
K_0	0.33	0.33	0.67	0.67
K_1	0.33	0.32	0.79	0.77
K_2	0.35	0.36	0.79	0.74
F test	NS	NS	S	NS
SEm ±	0.01	0.02	0.03	0.04
CD (0.05)	0.03	0.05	0.09	0.10

S = Significant; NS = Non significant; DAP = Days after planting

Table 4. Effect of N, P and K interactions on crop growth rate

Treatment	Crop growth rate (g m^{-2} day^{-1})			
	60 to 120 DAP		120 to 180 DAP	
	1996-97	1997-98	1996-97	1997-98
N_0P_0	0.24	0.24	0.31	0.27
N_0P_1	0.26	0.23	0.31	0.30
N_0P_2	0.25	0.22	0.41	0.43
N_1P_0	0.24	0.25	0.65	0.70
N_1P_1	0.30	0.37	0.70	0.65
N_1P_2	0.43	0.42	0.76	.075
N_2P_0	0.40	0.42	1.13	1.08
N_2P_1	0.41	0.39	1.17	1.22
N_2P_2	0.48	0.50	1.26	1.17
F test	S	S	NS	NS
N_0K_0	0.23	0.22	0.29	0.29
N_0K_1	0.27	0.25	0.36	0.34
N_0K_2	0.24	0.21	0.38	0.37
N_1K_0	0.31	0.33	0.66	0.69
N_1K_1	0.31	0.32	0.77	0.75
N_1K_2	0.35	0.39	0.69	0.67
N_2K_0	0.44	0.44	1.04	1.04
N_2K_1	0.40	0.38	1.24	1.23
N_2K_2	0.46	0.48	1.29	1.19
F test	NS	NS	NS	NS
P_0K_0	0.30	0.31	0.58	0.65
P_0K_1	0.29	0.28	0.81	0.75
P_0K_2	0.29	0.31	0.71	0.65
P_1K_0	0.32	0.32	0.67	0.64
P_1K_1	0.33	0.31	0.78	0.83
P_1K_2	0.33	0.35	0.73	0.70
P_2K_0	0.36	0.36	0.75	0.73
P_2K_1	0.37	0.36	0.77	0.74
P_2K_2	0.43	0.42	0.91	0.89
F test	NS	NS	NS	NS
SEm ±	0.02	0.03	0.053	0.064
CD (0.05)	0.06	0.09	-	-

S = Significant; NS = Non significant; DAP = Days after planting

Table 5. Effect of nutrients on uptake of N, P and K by plants and dry rhizome yield of ginger

Treatment	N (kg ha^{-1})		P (kg ha^{-1})		K (kg ha^{-1})		Yield (dry kg ha^{-1})
	1996-97	1997-98	1996-97	1997-98	1996-97	1997-98	(pooled mean)
N_0	64.44	43.88	11.63	13.57	80.76	82.34	2245.59
N_1	80.07	87.22	11.98	13.23	85.67	82.57	2896.39
N_2	103.06	108.5	12.21	13.65	88.54	83.89	3087.28
F test	S	S	S	NS	S	NS	S
P_0	81.93	78.96	8.93	9.45	83.88	83.90	2602.24
P_1	82.96	80.44	11.34	15.11	84.52	82.90	2712.40
P_2	82.67	80.27	15.54	15.89	86.57	82.01	2914.80
F test	NS	NS	S	S	NS	NS	S
K_0	82.25	79.28	11.76	13.33	76.43	54.23	2620.00
K_1	83.01	79.68	12.19	13.52	80.07	89.53	2730.61
K_2	82.30	80.72	11.86	13.60	98.47	105.04	2878.65
F test	NS	NS	NS	NS	S	S	S
SEm ±	0.795	1.009	0.159	0.126	1.065	1.370	37.44
CD (0.05)	2.252	2.859	0.451	0.358	3.016	3.882	105.38

S = Significant; NS = Non significant

years of study. In general, high levels of P and K_2O exerted marked influence on CGR. N x P interaction was significant during both the years (Table 4). It is also evident that at higher levels of N, potassium enhanced the CGR.

Uptake of nutrients

The uptake of nitrogen, phosphorus and potassium was significantly increased with higher rate of application (Table 5). Higher uptake of nutrients under N 150 kg ha^{-1}, P_2O_5 100 kg ha^{-1} and K_2O 100 kg ha^{-1} was attributed to better availability of nutrients, which reflected in better growth and rhizome yield. Since ginger is an exhaustive crop, it responds greatly to manure application (Sushama & Jose 1994). Higher K content in the leaf was found to be associated with higher yield in ginger (Muralidharan *et al.* 1974). No significant interaction was observed on the uptake of nutrients.

Yield

Higher levels of N, P_2O_5 and K_2O and its interactions significantly influenced rhizome yield (Tables 5 & 6). Enhanced nitrogen application, from 75 kg ha^{-1} to 150 kg ha^{-1} increased rhizome yield to 290 kg ha^{-1}. Similar findings have been reported by Muralidharan *et al.* (1974), Lee *et al.* (1981) and Ancy & Jayachandran (1996). Application of phosphorus significantly increased the rhizome yield. Enhanced P application, from 50 kg ha^{-1} to 100 kg ha^{-1} increased rhizome yield to 202 kg ha^{-1}. Aiyadurai (1966) reported increase in yield due to higher rates of P application. The increase in fresh rhizome yield due to enhancement of K from 50 kg ha^{-1} to 100 kg ha^{-1} was to the tune of 148 kg ha^{-1}. Positive influence of K application on increasing rhizome yield was reported by Singh *et al.* (1993). Sushama & Jose (1994) reviewed the nutrition of ginger and grouped

Table 6. Effect of interactions on yield of ginger

Nutrient level	Yield (dry kg ha^{-1})	Nutrient level	Yield (dry kg ha^{-1})	Nutrient l level	Yield (dry kg ha^{-1})
N_0P_0	2204.17	N_0K_0	2138.94	P_0K_0	2506.06
N_0P_1	2262.22	N_0K_1	2304.33	P_0K_1	2634.11
N_0P_2	2770.39	N_0K_2	2293.50	P_0K_2	2666.56
N_1P_0	2728.17	N_1K_0	2776.44	P_1K_0	2675.78
N_1P_1	2980.39	N_1K_1	2923.39	P_1K_1	2777.50
N_1P_2	2980.61	N_1K_2	2989.33	P_1K_2	2684.94
N_2P_0	2874.39	N_2K_0	2944.61	P_2K_0	2678.14
N_2P_1	2895.61	N_2K_1	2964.11	P_2K_1	2780.22
N_2P_2	3491.83	N_2K_2	3353.11	P_2K_2	3284.44
F test	S	F test	S	F test	S
SEm ±	64.86				
CD (0.05)	182.52				

S = Significant

ginger as an exhaustive crop which responds greatly to manure application. Interaction effects clearly indicated that when N is increased, there should be a proportionate increase in P and K for obtaining higher yield. A nutrient trial conducted under artificial shade revealed the necessity of increasing fertilizer dose to 150 per cent of the existing rate (Ancy & Jayachandran 1996) and higher uptake of N and K under shade was also reported in ginger (KAU 1992). Higher uptake of nutrients under shaded condition increased growth and rhizome yield. Several reports indicated an increase in rhizome yield when ginger was grown under artificial shade (Susan Varughese 1989; Jayachandran *et al.* 1991) and intercropped in coconut garden (Ravisanker & Muthuswami 1988; KAU 1992). Application of higher levels of N, P and K to intercropped ginger favoured increase in leaf number, LAI, DMP and CGR, which might have resulted in higher yield. The study highlights that the existing NPK recommendation for ginger for open condition is insufficient for ginger grown as intercrop in coconut garden. A fertilizer dose of 150 kg N : 100 kg P_2O_5 : 100 kg K_2O ha^{-1} can be adopted for ginger grown as an intercrop in coconut garden.

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